Time Slice versus Hemispheric Cloud Amount: Impact on Statistics and BBHRP Calculations

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Introduction

ARM measures the vertical distribution of clouds using vertically pointing narrow field-of-view active sensors. Statistics of cloud occurrence are calculated using some time period and counting the times when a cloud is detected in the beam versus the total time. Similarly, BBHRP uses 1-minute intervals of MicroBase retrievals for the radiative calculations which are then averaged into 30-minute results, thus the BBHRP fluxes inherently include a time-slice cloud amount. However, the BBHRP 30-minute results are then tested against broadband hemispheric FOV radiometer measurements, which are inherently affected by cloud presence in the wider FOV. Kassianov et al. (2004) have shown that the time-slice cloud amount is limited in representing the local cloud field affecting the hemispheric measurements. We investigate the impact of this disparity on the hourly cloud statistics included in the Modeling Best Estimate product and the 30-minute average BBHRP surface radiation comparison residuals.

Screening for Optically Thin Cloud

- CMBE (Climate Modeling Best Estimate) cloud amount based on ARSCL, including MPL which is more sensitive to optically thin cloud (t<0.15) than other instruments (e.g. TSI, SW Flux Analysis, etc.) The MMCR-based MicroBase retrievals used in BBHRP include precipitation (e.g. drizzle) which is also not classified as cloud by the other instruments.
- We use the difference between measured and SW Flux Analysis clear-sky diffuse over corresponding total SW ratio (diffuse ratio) to screen for when all instruments will detect clouds (Fig.1), and thus a comparison is possible.

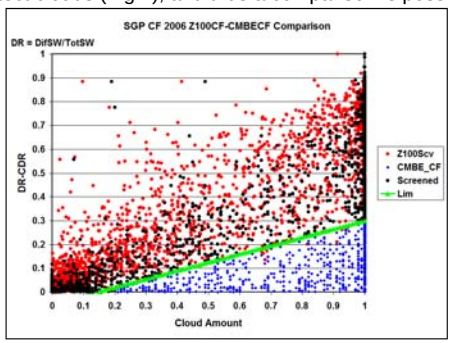


Figure 1: The difference between the measured and clear-sky diffuse ratio is used to screen for transparent clouds too optically thin to be detected by the TSI and SW Flux Analysis (SWFA). Only data falling above the limit (green) are compared.

Cloud Amount Comparisons

- All comparisons use screening as in Figure 1

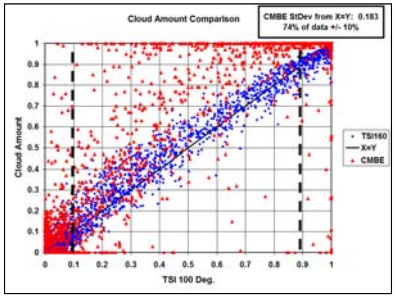
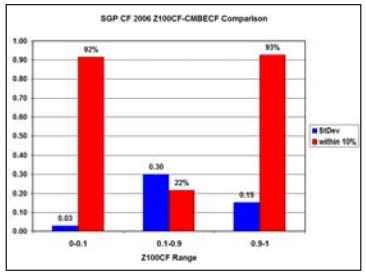


Figure 2: TSI 160° FOV (blue) and CMBE (red) cloud amounts compared to TSI 100° FOV (X-axis) hourly averages. Overall, 74% of the CMBE data falls within +/- 10% cloud amount of the TSI 100° FOV value, with a standard deviation from X=Y of 18% cloud amount.

Figure 3: The CMBE and TSI 100° FOV averages agree well for nearly clear and nearly overcast conditions, when over 90% of the data agree within +/- 10% cloud amount. For partly cloudy skies, however, only about 22% of the time do the two agree to within +/- 10%, showing that the "pencil beam" includes larger uncertainty.



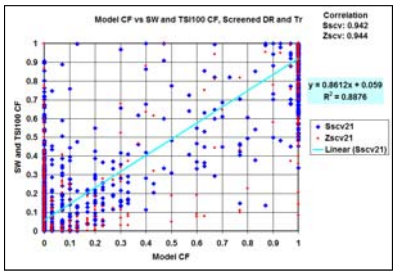
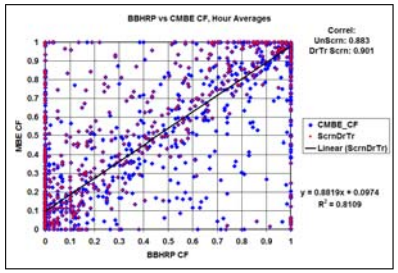


Figure 4: Similar to Figure 2, the BBHRP half-hourly cloud amount (X-axis) based on MicroBase agrees better for nearly clear and nearly overcast conditions, and not as well for partly cloudy skies. Overall 76% of the data fall within +/- 10% of the SWFA cloud amount (blue).

Figure 5: Comparison of the BBHRP hourly cloud amount (X-axis) with CMBE ARSCL-based cloud amount shows that overall 79% of the screened data (red) fall within +/- 10% of each other. Though both are from NFOV measurements, the scatter here is largely due to sampling differences and MicroBase not including Lidar data.



Reference:
Kassianov, E., C. N. Long, and M. Ovtchinnikov, (2004): Cloud Sky Cover versus Cloud Fraction: Whole-Sky Simulations and Observations, JAM, 44, 86-98.

Summary

- **Time series cloud amount well represents clear and overcast cases, but not so for partly cloudy skies.**
- **Despite the above, cloud amount differences exhibit only small correlation with BBHRP total SW measurement/model differences (0.1-0.2 for all-sky, 0.25 for model clear-sky).**
- **Larger correlation is found for diffuse SW residuals (0.5-0.6). Thus the primary influence of cloud amount BBHRP errors are in the diffuse SW.**
- **Given the above, we speculate that the greater factors involve the direct SW component, which tends to dominate the total SW when present:**
  - **Is the cloud occurrence detected over head representative of that in front of the sun?**
  - **Are the cloud microphysics retrieved overhead representative of the cloudiness in front of the sun?**

Residuals versus Cloud Amount Difference

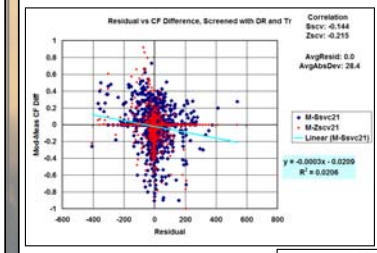
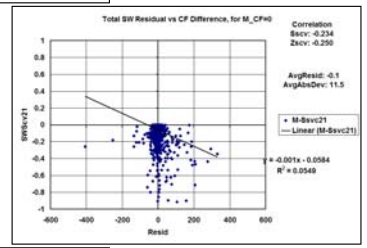


Figure 6: Total SW BBHRP minus measured residual differences (X-axis) versus BBHRP minus larger FOV cloud amount difference. Unexpectedly, there is only small correlation between the two for all-sky. While the residuals themselves average to zero, there are cases with disagreements of 100s of Wm^{-2}, producing an average absolute deviation of over 28 Wm^{-2}.

Figure 7: Similar to Figure 6, but for only times when the BBHRP cloud amount indicates clear skies (CF=0), when one would expect the maximum effect of non-detected clouds on the residuals. Here the correlation still increases to only 0.23 to 0.25.



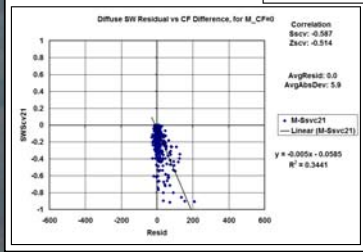


Figure 8: Similar to Figure 7, but for diffuse SW residuals. In the case of the diffuse SW, there is now significant correlation between the cloud amount differences and the residuals. The results of Figures 6 through 8 suggest that it is the direct SW component that dominates the residual SW differences.